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Intro

“Industrialization is, I am afraid, going to be a curse for mankind ... God forbid that India should ever take to industrialism after the manner of the West. The economic imperialism of a single tiny island kingdom (England) is today [1928] keeping the world in chains. If an entire nation of 300 millions took to similar economic exploitation, it would strip the world bare like locusts. ... Industrialization on a mass scale will necessarily lead to passive or active exploitation of the villagers. ... The machine produces much too fast.”

Such were the views of the famous Indian nationalist and spiritual leader Mahatma Gandhi, who subsequently led his country to independence from British colonial rule by 1947, only to be assassinated a few months later. However, few people anywhere have agreed with India’s heroic figure. Since its beginning in Great Britain in the late eighteenth century, the idea of industrialization, if not always its reality, has been embraced in every kind of society, both for the wealth it generates and for the power it conveys. Even Gandhi’s own country, once it achieved its independence, largely abandoned its founding father’s vision of small-scale, village-based handicraft manufacturing in favor of modern industry. As the twenty-first century dawned, India was moving rapidly to develop a major high technology industrial sector. At that time, across the river from the site in New Delhi where Gandhi was cremated in 1948 a large power plant belched black smoke.

Few elements of Europe’s modern transformation held a greater significance for the history of humankind than the Industrial Revolution, which took place initially in the century and a half between 1750 and 1900. It drew upon the Scientific Revolution and accompanied the unfolding legacy of the French Revolution to utterly transform European society and to propel Europe into a position of global dominance. Not since the break-

through of the Agricultural Revolution some 12,000 years ago had human ways of life been so fundamentally altered. But the Industrial Revolution, unlike its agricultural predecessor, began independently in only one place, Western Europe, and more specifically Great Britain. From there, it spread far more rapidly than agriculture, though very unevenly, to achieve a worldwide presence in less than 250 years. Far more than Europe’s Christian religion, its democratic political values, or its capitalist economic framework, the techniques of its Industrial Revolution have been intensely sought after virtually everywhere.

In any long-term reckoning, the history of industrialization is very much an unfinished story. It is hard to know whether we are at the beginning of a movement leading to worldwide industrialization, stuck in the middle of a world permanently divided into rich and poor countries, or approaching the end of an environmentally unsustainable industrial era. Whatever the future holds, this chapter focuses on the early stages of an immense transformation in the global condition of humankind.

Explaining the Industrial Revolution

The global context for this epochal economic transformation lies in a very substantial increase in human numbers from about 375 million people in 1400 to about 1 billion in the early nineteenth century. Accompanying this growth in population was an emerging energy crisis, most pronounced in Western Europe, China, and Japan, as wood and charcoal, the major industrial fuels, became more scarce and their prices rose. In short, “global energy demands began to push against the existing local and regional ecological limits.” In broad terms, the Industrial Revolution marks a human response to that dilemma as fossil fuels replaced the earlier reliance on wind, water, wood, and the muscle power of people and animals. All of those had derived from “recently captured solar energy,” but now human ingenuity found the means to tap

as well the anciently stored solar energy of coal, oil, and natural gas. It was a breakthrough of unprecedented proportions that made available for human use immensely greater quantities of energy. It also wrought, of course, a mounting impact on the environment with which the world of the twenty-first century is increasingly occupied.

More immediately, however, that access to huge new sources of energy gave rise to an enormously increased output of goods and services. In Britain, where the Industrial Revolution began, industrial output increased some fiftyfold between 1750 and 1900. It was a wholly unprecedented and previously unimaginable jump in the capacity of human societies to produce wealth. Lying behind it was a great acceleration in the rate of technological innovation, not simply this or that invention the spinning jenny, power loom, steam engine, or cotton gin—but a “culture of innovation,” a widespread and almost obsessive belief that things could be endlessly improved.

Early signs of the technological creativity that spawned the Industrial Revolution appeared in eighteenth-century Britain, where a variety of innovations transformed cotton textile production. It was only in the nineteenth century, though, that Europeans in general and the British in particular more clearly forged ahead of the rest of the world. The great breakthrough was the coal-fired steam engine, which provided an inanimate and almost limitless source of power beyond that of wind, water, or muscle and could be used to drive any number of machines as well as locomotives and oceangoing ships. Soon the Industrial Revolution spread beyond the textile industry to iron and steel production, railroads and steamships, food processing, construction, chemicals, electricity, the telegraph and telephone, rubber, pottery, printing, and much more. Agriculture too was affected as mechanical reapers, chemical fertilizers, pesticides, and refrigeration transformed this most ancient of industries. Technical innovation occurred in more modest ways as well. Patents for horseshoes in the United States, for example,

grew from fewer than five per year before 1840 to thirty to forty per year by the end of the century. Furthermore, industrialization spread beyond Britain to continental Western Europe and then in the second half of the century to the United States, Russia, and Japan.

In the twentieth century, the Industrial Revolution became global as a number of Asian, African, and Latin American countries developed substantial industrial sectors. Oil, natural gas, and nuclear reactions joined coal as widely available sources of energy, and new industries emerged in automobiles, airplanes, consumer durable goods, electronics, computers, and on and on. It was a cumulative process that, despite periodic ups and downs, accelerated over time. More than anything else, this continuous emergence of new techniques of production and the economic growth that they made possible mark the past 250 years as a distinct phase of human history.

Why Europe?

The Industrial Revolution has long been a source of great controversy among scholars. Why did it occur first in Europe? Within Europe, why did it occur first in Great Britain? And why did it take place in the late eighteenth and nineteenth centuries? Earlier explanations that sought the answer in some unique and deeply rooted feature of European society, history, or culture have been challenged by world historians because such views seemed to suggest that Europe alone was destined to lead the way to modern economic life. This approach not only was Eurocentric and deterministic but also flew in the face of much recent research.

Historians now know that other areas of the world had experienced times of great technological and scientific flourishing. Between 750 and 1100 C.E., the Islamic world generated major advances in shipbuilding, the use of tides and falling water to generate power, papermaking, textile production, chemical technologies, water mills, clocks, and much more. India had long been the world center of cotton textile production, the first place to turn

sugarcane juice into crystallized sugar, and the source of many agricultural innovations and mathematical inventions. To the Arabs of the ninth century C.E., India was a “place of marvels.” More than either of these, China was clearly the world leader in technological innovation between 700 and 1400 C.E., prompting various scholars to suggest that China was on the edge of an industrial revolution by 1200 or so. For reasons much debated among historians, all of these flowerings of technological creativity had slowed down considerably or stagnated by the early modern era, when the pace of technological change in Europe began to pick up. But their earlier achievements certainly suggest that Europe was not alone in its capacity for technological innovation.

Nor did Europe enjoy any overall economic advantage as late as 1750. Over the past several decades, historians have carefully examined the economic conditions of various Eurasian societies in the eighteenth century and found them surprisingly alike. Economic indicators such as life expectancies, patterns of consumption and nutrition, wage levels, general living standards, widespread free markets, and prosperous merchant communities suggest broadly similar conditions across the major civilizations of Europe and Asia. Thus Europe had no obvious economic lead, even on the eve of the Industrial Revolution. Rather, according to one leading scholar, “there existed something of a global economic parity between the most advanced regions in the world economy.”

A final reason for doubting any unique European capacity for industrial development lies in the relatively rapid spread of industrial techniques to many parts of the world over the past 250 years (a fairly short time by world history standards). Although the process has been highly uneven, industrialization has taken root, to one degree or another, in Japan, China, India, Brazil, Mexico, Indonesia, South Africa, Saudi Arabia, Thailand, South Korea, and elsewhere. Such a pattern weakens any suggestion that European culture or

society was exceptionally compatible with industrial development.

Thus contemporary historians are inclined to see the Industrial Revolution erupting rather quickly and quite unexpectedly between 1750 and 1850 (see Map 18.1). Two intersecting factors help to explain why this process occurred in Europe rather than elsewhere. One lies in certain patterns of Europe’s internal development that favored innovation. Its many small and highly competitive states, taking shape in the twelfth or thirteenth centuries, arguably provided an “insurance against economic and technological stagnation,” which the larger Chinese, Ottoman, or Mughal empires perhaps lacked. If so, then Western Europe’s failure to re-create the earlier unity of the Roman Empire may have acted as a stimulus to innovation.

Furthermore, the relative newness of these European states and their monarchs’ desperate need for revenue in the absence of an effective tax-collecting bureaucracy pushed European royals into an unusual alliance with their merchant classes. Small groups of merchant capitalists might be granted special privileges, monopolies, or even tax-collecting responsibilities in exchange for much-needed loans or payments to the state. It was therefore in the interest of governments to actively encourage commerce and innovation. Thus states granted charters and monopolies to private trading companies, and governments founded scientific societies and offered prizes to promote innovation. In this way, European merchants and other innovators from the fifteenth century onward gained an unusual degree of freedom from state control and in some places a higher social status than their counterparts in more established civilizations. In Venice and Holland, merchants actually controlled the state. By the eighteenth century major Western European societies were highly commercialized and governed by states generally supportive of private commerce. In short, they were well on their way toward capitalist economies—where buying and selling on the market was a widely established

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practice-before they experienced industrialization, Such internally competitive economies, coupled with a highly competitive system of rival states,

arguably fostered innovation in the new civilization taking shape in Western Europe.



The Early Phase of Europe's Industrial Revolution

From its beginning in Great Britain, industrialization spread by 1850 across northwestern Europe to include parts of France, Germany, Belgium, Bohemia, and Italy.

Europe's societies, of course, were not alone in developing market-based economies by the eighteenth century. Japan, India, and especially China were likewise highly commercialized or market driven. However, in the several centuries after

1500, Western Europe alone "found itself at the hub of the largest and most varied network of exchange in history." Widespread contact with culturally different peoples was yet another factor that historically has generated extensive change

and innovation. This new global network, largely the creation of Europeans themselves, greatly energized European commerce and brought Europeans into direct contact with peoples around the world.

For example, Asia, home to the world's richest and most sophisticated societies, was the initial destination of European voyages of exploration. The German philosopher Gottfried Wilhelm Leibniz (1646-1716) encouraged Jesuit missionaries in China "not to worry so much about getting things European to the Chinese but rather about getting remarkable Chinese inventions to *us*." Inexpensive and well-made Indian textiles began to flood into Europe, causing one English observer to note: "Almost everything that used to be made of wool or silk, relating either to dress of the women or the furniture; of our houses, was supplied by the Indian trade." The competitive stimulus of these Indian cotton textiles was certainly one factor driving innovation in the British textile industry. Likewise, the popularity of Chinese porcelain and Japanese lacquerware prompted imitation and innovation in England, France, and Holland. Thus competition from desirable, high-quality, and newly available Asian goods played a role in stimulating Europe's Industrial Revolution.

In the Americas, Europeans found a windfall of silver that allowed them to operate in Asian markets. They also found timber, fish, maize, potatoes, and much else to sustain a growing population. Later, slave-produced cotton supplied an emerging textile industry with its key raw material at low prices, while sugar, similarly produced with slave labor, furnished cheap calories to European workers. "Europe's Industrial Revolution," concluded historian Peter Stearns, "stemmed in great part from Europe's ability to draw disproportionately on world resources." The new societies of the Americas further offered a growing market for European machine-produced goods and generated substantial profits for European merchants and entrepreneurs. None of the other

empires of the early modern era enriched their imperial heartlands so greatly or provided such a spur to technological and economic growth.

Thus the intersection of new, highly commercialized, competitive European societies with the novel global network of their own making provides a context for understanding Europe's Industrial Revolution. Commerce and cross-cultural exchange, acting in tandem, provided the seedbed for the impressive technological changes of the first industrial societies.

Why Britain?

If the Industrial Revolution was a Western European phenomenon generally, it clearly began in Britain in particular. The world's first Industrial Revolution unfolded spontaneously in a country that concentrated some of the more general features of European society. It was both unplanned and unexpected.

Britain was the most highly commercialized of Europe's larger countries. Its landlords had long ago "enclosed" much agricultural land, pushing out the small farmers and producing for the market. A series of agricultural innovations—crop rotation, selective breeding of animals, lighter plows, higher-yielding seeds—increased agricultural output, kept food prices low, and freed up labor from the countryside. The guilds, which earlier had protected Britain's urban artisans, had largely disappeared by the eighteenth century, allowing employers to run their manufacturing enterprises as they saw fit. Coupled with a rapidly growing population, these processes ensured a ready supply of industrial workers who had few alternatives available to them. Furthermore, British aristocrats, unlike their counterparts in Europe, had long been interested in the world of business, and some took part in new mining and manufacturing enterprises. British commerce, moreover, extended around the world, its large merchant fleet protected by the Royal Navy. The wealth of empire and global commerce, however,

were not themselves sufficient for spawning the Industrial Revolution, especially when we consider that Spain, the earliest beneficiary of American wealth, remained one of the more slowly industrializing European countries into the twentieth century.

British political life encouraged commercialization and economic innovation. Its policy of religious toleration, formally established in 1688, welcomed people with technical skills regardless of their faith, whereas France's persecution of its Protestant minority had chased out some of its most skilled workers. The British government favored men of business with tariffs to keep out cheap Indian textiles, with laws that made it easy to form companies and to forbid workers' unions, with roads and canals that helped create a unified internal market, and with patent laws that served to protect the interests of inventors. Checks on royal authority—trial by jury and the growing authority of parliament, for example—provided a freer arena for private enterprise than elsewhere in Europe.

Europe's Scientific Revolution also took a distinctive form in Great Britain in ways that fostered technological innovation. Whereas science on the continent was largely based on logic, deduction, and mathematical reasoning, in Britain it was much more concerned with observation, experiment, precise measurements, mechanical devices, and practical commercial applications. Discoveries about atmospheric pressure and vacuums, for example, played an important role in the invention

and improvement of the steam engine. Even though most inventors were artisans or craftsmen rather than scientists, in eighteenth-century Britain they were in close contact with scientists, makers of scientific instruments, and entrepreneurs, whereas in continental Europe these groups were largely separate. The British Royal Society, an association of "natural philosophers" (scientists) established in 1660, saw its role as one of promoting "useful knowledge." To this end, it established "mechanics' libraries," published broadsheets and pamphlets on recent scientific advances, and held frequent public lectures and demonstrations. The integration of science and technology became widespread and permanent after 1850, but for a century before, it was largely a British phenomenon.

Finally, several accidents of geography and history contributed something to Britain's Industrial Revolution. The country had a ready supply of coal and iron ore, often located close to each other and within easy reach of major industrial centers. Although Britain took part in the wars against Napoleon, the country's island location protected it from the kind of invasions that so many continental European states experienced during the era of the French Revolution. Moreover, Britain's relatively fluid society allowed for adjustments in the face of social changes without widespread revolution. By the time the dust settled from the immense disturbance of the French Revolution, Britain was well on its way to becoming the world's first industrial society.